J. Wang

December 31, 1997

Mr. Vernon Persson, Chief
Division of Safety of Dams
Department of Water Resources
P.O. Box 942836
Sacramento, CA 94236-0001

Dear Mr. Persson:

Subject: Leroy Anderson Dam, No. 72-9—Santa Clara County

ANNUAL SUMMARY REPORT AND ANALYSIS OF SURVEILLANCE DATA

- Piezometer and Monthly Rainfall Data from January 1993 through November 1997
- Monument Data from January 1993 through January 1997
- Spillway Underdrain Flow Data from May 1993 through November 1997

INTRODUCTION

This annual summary report provides an analysis of January 1997 through November 1997 surveillance data from Leroy Anderson Dam, No. 72-9. This report updates our initial "Interim Summary Report," dated January 10, 1997, and is the first of a new series of annual surveillance reports. Because one report per dam will be produced each month for review, this first annual report covers only part of a year (January through November for Anderson Dam). Future annual reports on Anderson Dam will cover 1-year periods, from November 1 to the following October 31.

Figure 1 shows the location of the surveillance points discussed below. Figure 2 shows both piezometers in cross section. Table 1 summarizes pertinent dam statistics. Table 2 summarizes 1993 to November 1997 piezometer and monthly rainfall data, Table 3 summarizes 1993 to November 1997 dam crest monument survey data, and Table 4 summarizes 1993 to November 1997 spillway underdrain flow data.

Piezometers are read monthly and the crest monuments are resurveyed annually. Seepage at the spillway underdrain discharge point is measured seasonally as it occurs. Reported rainfall is measured at Santa Clara Valley Water District (District) Rain Gauge No. 41-2073, located a few hundred feet southeast of the left abutment of Leroy Anderson Dam.

SUMMARY OF FOUNDATION AND EMBANKMENT CONDITIONS

Information in this section is based on Wahler Associates' 1986 Inspection and Safety Review report of Leroy Anderson Dam, prepared in accordance with requirements of the Federal Energy Regulatory Commission.

Foundation earth materials beneath the dam are rocks of the Jurassic-Cretaceous Franciscan Complex. Specifically, the lower right abutment is underlain by dense sandstone and shale, while the upper right abutment and upstream right abutment are underlain by soft, sheared serpentine. The serpentine extends from the upstream toe in the channel and cuts diagonally downstream across the right abutment. The serpentine/sandstone contact is characterized by a zone of crushed and faulted serpentine. Numerous faults mapped within the serpentine appear to be traces of the Coyote Creek fault system.

The dam embankment consists of a wide, central impervious core designated as Zones 2 and 3, flanked by upstream and downstream rockfill shells designated as Zones 1 and 4. Seepage control through the dam is provided by the downstream rockfill. A 20- to 30-foot wide strip drain was constructed on the foundation beneath Zone 3 on the left side of the channel section. It appears this drain may have been constructed to control seepage from several springs that were apparently encountered during construction.

PIEZOMETER DATA

Figure 3 is a plot of reservoir water levels versus piezometric surface data, and monthly rainfall data, from January 1993 through November 1997. This surveillance period represents roughly five rainy seasons with generally normal to above normal rainfall. The beginning of 1993 rainy season marked the end of a relatively long drought that began in about 1987. During the 1996-1997 rainy season, most of the rainfall occurred during October through January, with relatively dry conditions from February 1997 to November 1997. Piezometric levels generally increased over this period, probably in response to generally greater storage over longer intervals than in the immediate past. There is some indication of a 5- to 6-month lag time between reservoir peaks and subsequent piezometric highs. The lag time between reservoir lows and the subsequent piezometric lows appears to be about 1 to 2 months.

Pneumatic piezometers PPA-1 and PPA-2 appear to have provided reliable data during the entire surveillance period.

A review of the piezometric data indicates that the embankment and its foundation are performing satisfactorily with respect to seepage.

MONUMENT DATA

Due to extensive dam crest modifications in 1987 and 1988, the original 15 crest monuments were destroyed and 16 new dam crest monument locations (Monuments 16 through 31) were established.

In addition, three new monument locations (Monuments 13, 14, and 15) were established on the right and left spillway training walls (Figure 1).

Figures 4, 5, and 6 are plots of new crest monument displacement versus time for the period of July 20, 1988, through January 29, 1997, in the Z (settlement), X, and Y directions, respectively. (Figure 1 shows locations of the X and Y axes.) The July 20, 1988, date represents the first monument survey of the new monuments after the 1988 dam raise. Based on review comments of the District's recent interim dam surveillance reports, the Division of Safety of Dams (DSOD) requested that the District provide plots of monument survey data over the last 10 years. Because the dam crest data shown on Figures 4, 5, and 6 begins at 1988, these plots represent a period of approximately 10 years.

The following figures are new to our annual report for Anderson Dam. Figures 7 and 8 are plan views of crest monument lateral movement. Figure 9 is a plan view of spillway training wall lateral displacement. Because Monument 13 (located on the right training wall) was not accessible due to flow through the spillway, it was not surveyed in 1997. Figures 10 and 11 show vertical displacement of the crest monuments in cross section along the axis of the dam. Figure 12 is a cross section view of the spillway training wall vertical displacement.

Approximate maximum displacements experienced by the new crest monuments were: 0.25 feet in the negative X direction for Monuments 21 and 24 (measured on January 29, 1997, and May 22, 1996, respectively); 0.11 feet in the negative Y direction for Monuments 18 and 20 (measured on January 4, 1996); and 0.37 feet in the negative Z direction (settlement) for Monument 24 (measured on January 29, 1997).

Based on the District's annual evaluation of crest monument survey data, we have identified what appears to be continuous downstream displacement of the dam crest monuments. In a letter dated April 2, 1997, DSOD requested that the District continue surveillance to monitor this trend with respect to safe operation of the dam. Based on the 1997 data, the observed downstream movement appears to have stabilized somewhat since the May 1996 survey. During the period from May 1996 to January 1997, only monuments on the thickest section of the dam (Monuments 20, 21, 22, and 23) had moved downstream minor amounts; about 0.01 to 0.02 foot. The remaining monuments had either not moved since May 1996 or had moved slightly upstream. The District will continue to monitor this trend.

Except for the observed downstream movement of crest monuments, displacements due to consolidation settlement and lateral movement have been within reasonable limits for the period of record presented here. No other unusual trends are evident in the crest monument data.

SPILLWAY UNDERDRAIN FLOW DATA

Figure 13 is a plot of reservoir level versus spillway underdrain flow and monthly rainfall data from May 1, 1993, through November 19, 1997. Spillway underdrain flow has been measured when feasible by reading a water flowmeter installed on the central exit hole of the underdrain system. The discharge hole is located about 3 feet below the lip of the spillway terminus. During high reservoir stages, maximum reported seepage flows were 131 gallons per minute (gpm) on May 24, 1993, and

June 29, 1995; 158 gpm on May 16 and May 21, 1996; and 133 gpm on June 11, 1997. The measured flow is only a rough indication of total flow because other exit points also discharge water. Based on visual observation, it seems likely that the measured flow is between ⅓ and ½ of the total flow discharging from all underdrain exit points. It is not possible to observe underdrain discharges when the reservoir is spilling. Further studies are planned to evaluate the underdrain flows.

To protect the meter from damage, it is removed when the reservoir approaches spill. To prevent vandalism, the meter is removed when flows are low or cease during the summer months. This explains gaps in the data shown on Figure 13.

A brief report by Wahler Associates dated May 25, 1993, concluded that spillway underdrain flows were well within the range of past drain or weep hole flows into the original spillway, and no safety-related concerns exist because the spillway slab is well drained with substantial anchorage into the underlying bedrock.

VISUAL OBSERVATIONS

Visual observations are made by District employees during site visits for routine surveillance, operational, or other activities. No conditions were noted that warranted special attention during the period of January 1997 through November 1997. Engineers from DSOD last performed a site visit at Leroy Anderson Dam on November 5, 1996. According to Water Resources Supervisor Mr. Joe Aguilera, during their 1996 site visit, DSOD did not have any concerns regarding the safe operation of the dam.

LOCAL SEISMICITY DURING JANUARY 1997 THROUGH NOVEMBER 1997

A discussion of historic seismicity in the vicinity of Anderson Dam prior to 1996 is presented in our Interim report for the dam dated January 10, 1997. During January 1997 through November 1997, there were no significant earthquakes in the vicinity of Anderson Dam. Significant earthquakes are defined as those with local magnitudes (M_L) of about 5 or greater within about 50 miles of District Dams. The largest earthquakes in the Southern San Francisco Bay Area since the May 21, 1996, earthquake ($M_L = 4.9$) consisted of two earthquakes of approximate magnitude 4.0 (see Figure 14). A magnitude 4.2 event occurred approximately 25 miles southeast of the dam (in the Hollister area) on March 22, 1997, and a magnitude 4.1 event occurred about 13 miles south of the dam (in the Gilroy area) on July 17, 1997. Because the crest monuments were surveyed in January 1997, prior to the earthquakes, any possible response would not show up on the monument positions depicted on Figures 4, 5, and 6. Because accelerations from these earthquakes were not significant enough to trigger the strong motion instruments at the dam, no displacements of the monuments area expected from the earthquakes.

CHANGES IN SURVEILLANCE PROGRAM, DAM AND APPURTENANT STRUCTURES, AND OPERATIONS AND MAINTENANCE

Overall, for the period January 1997 through November 1997, no significant modifications of the dam or appurtenant structures occurred, and no operational changes were made that would impact the surveillance data or its interpretation.

A minor modification during the period of this report consisted of replacing the 42-inch diameter outlet butterfly valve with a steel seated butterfly valve on October 6, 1997. Also, during the 1996-1997 winter, the District repaired an area located approximately 800 feet downslope of the spillway that had been damaged by large discharge flows. After reservoir overflow is discharged from the spillway terminus, it flows along a rock-lined channel for approximately 800 feet and then over a rock cliff, producing a waterfall. The base of the rock cliff had been undermined by high discharge flow from the spillway during and following unusually intense winter storms. The following is a summary of the event and corrective repair work, provided by Associated Civil Engineer Ms. Mary Stone of Operations and Maintenance.

"Anderson Reservoir began spilling January 23, 1997, with a maximum flow of 7,056 cubic feet per second on January 26, the highest flows since the dam was constructed in 1952. Spillway flows ended on January 26. On January 28 at 9 p.m., the District received a report of erosion on the south side of the earth spillway channel approximately 850 feet downstream of the end of the concrete spillway. Two sites in the area were found to be eroding which could eventually result in diverting water. Access to one site was started on January 30 and the repair completed on February 4. Flows in the channel had receded enough to start building a ramp into the earth channel and start emergency repairs on the second site on February 4. Repairs were completed on February 8 with 910 cubic yards of earthfill material and 152 truckloads of ¼-ton to 5-ton rock riprap protection in place. The site was cleaned up and equipment removed on February 12."

CONCLUSIONS

Review of the surveillance data from Leroy Anderson Dam indicates acceptable performance of the dam and spillway for the period of this report. Surveillance will continue on the schedule indicated herein, but crest monument surveys will be performed annually in October to bring the monument survey date closer to the date of this report. Maximum "allowable" values for the piezometers, crest monuments, and spillway discharge will be established in the next annual summary report.

Based on the 1997 dam crest monument survey data, the previously observed downstream movement appears to have stabilized somewhat since the May 1996 survey. During the period from May 1996 to January 1997, only monuments on the thickest section of the dam (Monuments 20, 21, 22, and 23) had moved downstream minor amounts; about 0.01 to 0.02 foot. The remaining monuments had either not moved since May 1996 or had moved slightly upstream. The District will continue to monitor this trend.

ACKNOWLEDGMENTS

Engineering Geologist Mr. James L. Nelson of Pacific Rim Geologic (Hollister, California) assisted in evaluating and updating the 1996-1997 surveillance data and preparing this report.

Sincerely,

ORIGINAL SIGNED BY

Robert E. Tepel
Engineering Geologist

Attachments:

1. Table 1—Pertinent Dam Statistics (As-built modifications, 1988)
2. Table 2—1993 to November 1997 Piezometer and Monthly Rainfall Data
3. Table 3—1993 to 1997 Monument Survey Data
4. Table 4—1993 to 1997 Spillway Underdrain Flow Data
5. Figure 1—Sketch Plan
6. Figure 2—Cross Section
7. Figure 3—Reservoir Water Level, Piezometric Surfaces, and Monthly Rainfall, January 1993 through November 1997
8. Figure 4—Monument Z Direction (Vertical) Displacement Versus Time, July 1988 to January 1997
9. Figure 5—Monument X Direction Displacement Versus Time, July 1988 to January 1997
10. Figure 6—Monument Y Direction Displacement Versus Time, July 1988 to January 1997
11. Figure 7—Downstream Crest Monument Lateral Location Surveys in Plan View, June 1991 through January 1997
12. Figure 8—Upstream Crest Monument Lateral Location Surveys in Plan View, June 1991 through January 1997
13. Figure 9—Spillway Training Wall Monument Lateral Location Surveys in Plan View, June 1991 through January 1997
14. Figure 10—Downstream Crest Monument Vertical Location Surveys in Section View, June 1991 through January 1997
15. Figure 11—Upstream Crest Monument Vertical Location Surveys in Section View, June 1991 through January 1997
16. Figure 12—Spillway Training Wall Monument Vertical Location Surveys in Section View, June 1991 through January 1997
17. Figure 13—Reservoir Level, Spillway Underdrain Flow, and Monthly Rainfall, May 1993 to November 1997
18. Figure 14 - Regional Fault Map, Showing Approximate $M_L = 4.0$ Earthquakes within 50 Miles of Leroy Anderson Dam, January 1997 through November 1997

cc/att: J. Sutcliffe, L. Moll, M. Klemencic, T. Dean, G. Faler, J. Wang, J. Aguilera, R. Tepel, File

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TABLE 1
Pertinent Dam Statistics (As-built modifications, 1988)
Leroy Anderson Dam
Page 1 of 1

DSOD No.	Year Completed	Type	Dam Height ft	Dam Crest Length ft	Storage Capacity (acre-ft)	Dam Crest Elev. ft	Spillway Crest Elev. ft	Total Freeboard ft
72-9	1950	Rolled Earth & Rock Fill	240	1,385	89,073	643.5	625.0	18.5

Note: basis of elevations is NGVD 1929

TABLE 2
1993 to November 1997 Piezometer and Monthly Rainfall Data
Leroy Anderson Dam
Page 1 of 2

Date	Reservoir Level	PPA-1	PPA-2	Monthly*
	(ft)	Piezometric Surface Elevation (ft)		Rainfall (in)
01/20/93	546.52	549.47	470.81	9.48
02/17/93	589.48	550.16	471.27	6.59
03/17/93	617.05	550.63	474.73	2.36
04/20/93	623.58	551.09	AH	0.47
05/19/93	620.55	552.24	478.20	0.67
06/16/93	618.50	552.71	479.81	0.64
07/14/93	617.56	551.09	482.82	0.00
08/18/93	614.85	555.25	483.51	0.00
09/16/93	609.55	556.17	AH	0.00
10/28/93	603.25	561.25	488.36	0.43
11/18/93	603.02	559.87	AH	1.70
12/20/93	602.72	560.33	490.90	1.50
01/18/94	601.75	564.26	489.98	1.88
02/17/94	602.18	565.18	491.13	4.35
03/23/94	603.48	565.87	491.60	0.55
04/26/94	599.85	566.57	491.83	0.91
05/17/94	595.62	566.57	491.83	1.54
06/22/94	589.02	567.03	492.06	0.00
07/20/94	586.82	564.72	489.52	0.00
08/16/94	584.22	565.87	491.60	0.00
09/19/94	580.68	564.95	489.05	0.00
10/12/94	578.52	566.33	489.75	0.39
11/16/94	571.98	564.95	489.05	2.02
12/15/94	571.05	564.95	488.13	1.50
01/17/95	583.02	563.10	487.21	11.11
02/15/95	606.28	562.64	489.05	0.59
03/15/95	621.42	562.18	489.29	9.09
04/18/95	624.28	565.64	492.52	1.44
05/17/95	624.43	565.41	494.37	0.56
06/14/95	624.29	572.11	496.22	0.48
07/17/95	622.28	574.19	495.52	0.00
08/15/95	619.31	576.04	498.76	0.00
09/19/95	614.78	576.96	498.99	0.00
10/17/95	608.98	576.73	497.83	0.12
11/15/95	604.66	AH	496.22	0.00
12/18/95	604.68	574.88	497.14	6.34
01/19/96	603.21	571.19	495.98	3.34
02/16/96	615.64	572.11	495.29	7.57
03/18/96	624.64	572.57	497.37	2.44

TABLE 2
1993 to November 1997 Piezometer and Monthly Rainfall Data
Leroy Anderson Dam
Page 2 of 2

Date	Reservoir Level (ft)	PPA-1	PPA-2	Monthly* Rainfall (in)
		Piezometric Surface Elevation (ft)		
04/15/96	624.31	575.34	497.60	0.94
05/20/96	623.13	576.50	498.29	1.69
06/17/96	618.37	575.57	498.76	0.00
07/15/96	613.55	577.65	500.14	0.00
8/19/96	607.83	579.96	499.91	0.00
9/12/96	605.22	576.96	499.45	0.00
10/17/96	599.42	575.81	499.68	1.46
11/19/96	599.26	573.73	497.60	2.39
12/06/96	597.77	537.50	496.22	7.28
01/16/97	623.36	573.73	498.29	11.11
02/18/97	623.88	574.42	500.14	0.08
03/17/97	618.66	575.34	500.84	0.16
04/14/97	618.44	577.19	500.37	0.00
05/15/97	617.20	576.73	498.53	0.16
06/24/97	614.51	573.96	501.07	0.04
07/15/97	611.56	579.96	501.07	0.00
08/18/97	604.37	578.58	500.60	0.08
09/23/97	599.42	576.96	500.84	0.00
10/14/97	596.79	575.57	496.91	0.40
11/19/97	592.35	574.42	497.37	4.22

Notes:
1) basis of elevations is NGVD 1929
2) * = total rainfall at end of indicated month in Date column
3) AH = anomalously high reading

TABLE 3
1993 to 1997 Monument Survey Data
Leroy Anderson Dam
Page 1 of 1

Date	Monument Z Direction (Vertical) Displacement (feet)																		
	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
01/27/93	0.01	-0.03	-0.03	-0.01	-0.09	-0.11	-0.27	-0.21	-0.32	-0.26	-0.23	-0.35	-0.18	-0.16	-0.09	-0.05	-0.04	-0.04	-0.06
01/11/94	-0.02	-0.01	-0.01	0.01	-0.08	-0.07	-0.24	-0.18	-0.29	-0.25	-0.22	-0.35	-0.20	-0.16	-0.11	-0.06	-0.04	-0.03	-0.05
12/05/94	NR	NR	NR	0.02	-0.06	-0.06	-0.23	-0.17	-0.29	-0.24	-0.18	-0.30	-0.14	-0.13	-0.06	-0.02	0.00	0.02	NR
01/04/96	NR	NR	NR	-0.05	-0.12	-0.11	-0.25	-0.18	-0.30	-0.25	-0.19	-0.31	-0.14	-0.13	-0.07	-0.04	-0.03	-0.02	-0.01
05/22/96*	NR	NR	NR	0.01	-0.06	-0.04	-0.20	-0.15	-0.27	-0.24	-0.18	-0.30	-0.13	-0.12	-0.05	-0.01	-0.01	0.01	-0.01
01/29/97	NR	-0.08	-0.03	0.02	-0.05	-0.06	-0.26	-0.19	-0.34	-0.30	-0.22	-0.37	-0.18	-0.17	-0.10	-0.08	-0.03	-0.01	-0.02

Date	Monument X Direction Displacement (feet)																		
	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
01/27/93	-0.10	-0.03	-0.03	-0.09	-0.12	-0.04	-0.12	-0.03	-0.09	-0.02	-0.07	-0.12	-0.01	-0.06	-0.02	-0.06	-0.05	-0.06	-0.06
01/11/94	-0.07	-0.06	-0.04	-0.09	-0.13	-0.07	-0.18	-0.09	-0.17	-0.08	-0.12	-0.17	-0.04	-0.09	-0.03	-0.06	-0.04	-0.06	-0.05
12/05/94	-0.05	-0.03	-0.03	-0.09	-0.13	-0.06	-0.17	-0.08	-0.16	-0.07	-0.12	-0.18	-0.04	-0.09	-0.03	-0.07	-0.05	-0.06	-0.06
01/04/96	-0.03	0.01	0.00	-0.09	-0.14	-0.09	-0.22	-0.13	-0.21	-0.12	-0.15	-0.23	-0.06	-0.12	-0.03	-0.08	-0.06	-0.08	-0.07
05/22/96*	NR	NR	NR	-0.10	-0.13	-0.10	-0.24	-0.15	-0.23	-0.12	-0.19	-0.25	-0.09	-0.15	-0.05	-0.10	-0.08	-0.09	-0.07
01/29/97	NR	-0.02	-0.03	-0.10	-0.15	-0.11	-0.24	-0.16	-0.25	-0.14	-0.20	-0.24	-0.09	-0.14	-0.05	-0.09	-0.07	-0.07	-0.08

Date	Monument Y Direction Displacement (feet)																		
	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
01/27/93	-0.07	-0.07	-0.06	-0.06	-0.07	-0.10	-0.06	-0.10	-0.05	-0.05	-0.01	0.00	-0.02	-0.01	-0.03	-0.03	-0.05	-0.04	-0.06
01/11/94	-0.08	-0.05	-0.04	-0.06	-0.07	-0.10	-0.06	-0.09	-0.02	-0.04	0.00	0.01	0.01	-0.01	-0.01	-0.04	-0.03	-0.03	-0.05
12/05/94	-0.09	-0.07	-0.07	-0.06	-0.07	-0.10	-0.06	-0.10	-0.05	-0.06	0.00	0.01	-0.01	-0.01	-0.01	-0.04	-0.04	-0.04	-0.05
01/04/96	-0.07	-0.09	-0.04	-0.06	-0.08	-0.11	-0.06	-0.11	-0.04	-0.06	0.00	0.02	0.00	-0.01	-0.02	-0.04	-0.06	-0.05	-0.06
05/22/96*	NR	NR	NR	-0.05	-0.04	-0.06	-0.02	-0.05	0.01	-0.01	0.02	0.02	-0.01	-0.03	-0.04	-0.06	-0.06	-0.06	-0.07
01/29/97	NR	-0.05	-0.04	-0.04	-0.05	-0.07	-0.03	-0.06	0.00	-0.02	0.03	0.03	0.01	0.00	-0.02	-0.03	-0.03	-0.04	-0.05

Notes:

1) Negative vertical displacement signifies settlement
2) Positive vertical displacement signifies heave
3) Y direction displacement signifies longitudinal movement
4) Negative X direction displacement signifies downstream movement
5) Positive X direction displacement signifies upstream movement
6) NR = monument survey data not recorded
7) Displacement is net movement since 1988
8) * = special monument survey after May 21, 1996 earthquake

TABLE 4
1993 to 1997 Spillway Underdrain Flow Data
Leroy Anderson Dam
Page 1 of 3

Date	Reservoir Level (ft)	Underdrain Flow (gpm)	Date	Reservoir Level (ft)	Underdrain Flow (gpm)	Date	Reservoir Level (ft)	Underdrain Flow (gpm)
05/21/93	620.42	87	06/29/93	618.15	122	10/01/93	607.02	82
05/22/93	620.32	126	06/30/93	618.15	121	10/04/93	606.48	80
05/23/93	620.22	120	07/01/93	618.12	122	10/08/93	605.88	79
05/24/93	620.15	131	07/02/93	618.08	122	10/11/93	605.48	78
05/25/93	620.12	125	07/03/93	618.02	121	10/14/93	605.12	76
05/26/93	620.02	124	07/04/93	617.98	121	10/18/93	604.75	76
05/27/93	619.95	124	07/05/93	617.95	121	10/21/93	604.32	75
05/28/93	619.85	123	07/06/93	617.92	121	10/25/93	603.62	74
05/29/93	619.78	124	07/07/93	617.88	121	10/28/93	603.25	72
05/30/93	619.72	123	07/08/93	617.85	121	02/22/94	602.68	66
05/31/93	619.62	124	07/09/93	617.82	121	02/24/94	602.68	43
06/01/93	619.55	123	07/11/93	617.72	121	02/28/94	604.18	60
06/02/93	619.45	123	07/12/93	617.68	121	03/03/94	604.68	63
06/03/93	619.35	123	07/13/93	617.65	121	03/07/94	604.05	65
06/04/93	619.28	124	07/14/93	617.58	121	03/10/94	603.58	64
06/05/93	619.22	124	07/15/93	617.55	121	03/17/94	603.52	63
06/06/93	619.15	124	07/16/93	617.52	121	03/21/94	603.52	62
06/07/93	619.12	123	07/19/93	617.42	120	03/24/94	603.48	63
06/08/93	619.05	124	07/22/93	617.28	120	03/28/94	603.55	63
06/09/93	618.98	113	07/27/93	617.15	120	03/31/94	603.52	61
06/10/93	618.92	126	07/29/93	617.08	120	04/04/94	603.52	61
06/11/93	618.85	122	08/02/93	616.95	120	04/07/94	603.22	61
06/12/93	618.78	122	08/06/93	616.72	120	04/11/94	602.58	59
06/13/93	618.72	103	08/09/93	616.28	120	04/14/94	602.08	60
06/14/93	618.65	125	08/12/93	615.82	118	04/18/94	601.38	53
06/15/93	618.58	122	08/16/93	615.15	116	04/21/94	600.75	39
06/16/93	618.55	122	08/19/93	614.68	114	04/25/94	599.95	37
06/18/93	618.42	122	08/23/93	614.05	112	04/28/94	599.55	34
06/19/93	618.42	121	08/27/93	613.32	109	05/02/94	598.82	32
06/20/93	618.38	121	08/30/93	612.65	107	05/05/94	598.32	35
06/21/93	618.35	123	09/02/93	612.05	104	05/09/94	597.65	31
06/22/93	618.32	121	09/07/93	611.18	100	05/12/94	596.95	26
06/23/93	618.32	121	09/09/93	610.82	94	05/16/94	595.88	24
06/24/93	618.28	122	09/13/93	610.05	91	05/19/94	595.28	28
06/25/93	618.28	122	09/16/93	609.55	88	05/23/94	594.45	24
06/26/93	618.28	123	09/20/93	609.02	87	05/26/94	593.65	21
06/27/93	618.25	121	09/23/93	608.45	86	05/31/94	592.05	17
06/28/93	618.22	122	09/27/93	607.72	84	06/02/94	591.52	3

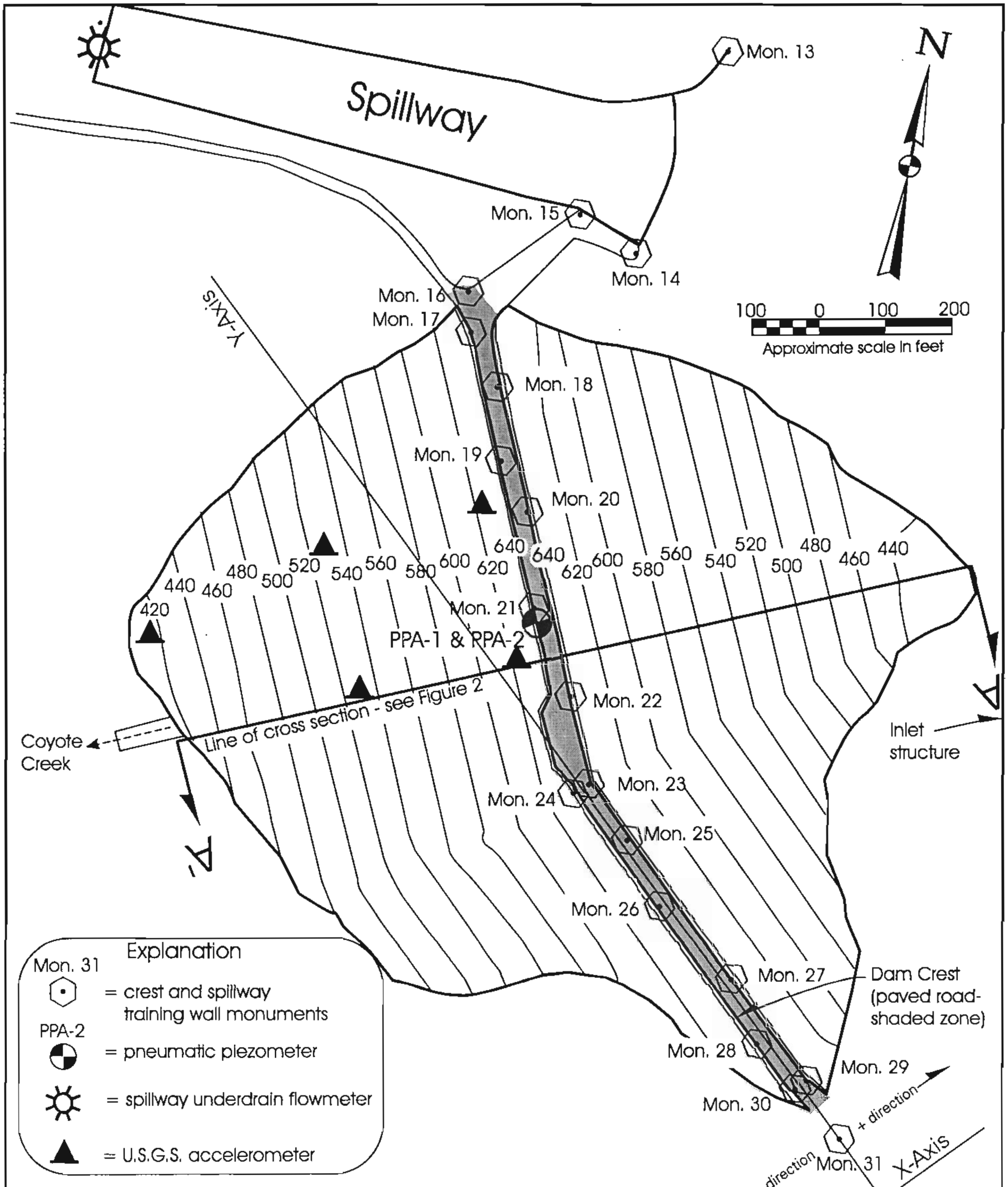
TABLE 4
1993 to 1997 Spillway Underdrain Flow Data
Leroy Anderson Dam
Page 2 of 3

Date	Reservoir Level (ft)	Underdrain Flow (gpm)	Date	Reservoir Level (ft)	Underdrain Flow (gpm)	Date	Reservoir Level (ft)	Underdrain Flow (gpm)
06/06/94	591.02	2	09/05/95	616.78	116	06/17/96	618.37	143
06/09/94	590.65	0	09/07/95	616.62	116	06/20/96	617.90	142
06/16/94	589.78	0	09/18/95	614.95	114	06/25/96	617.06	139
06/23/94	588.92	0	09/25/95	613.72	104	06/27/96	616.74	137
03/02/95	606.42	37	09/28/95	613.28	102	07/01/96	616.08	121
03/06/95	606.48	38	10/02/95	612.78	101	07/11/96	614.28	110
03/09/95	606.55	39	10/12/95	610.23	95	07/15/96	613.55	125
03/11/95	612.78	52	10/16/95	609.20	87	07/19/96	612.87	121
05/11/95	624.02	109	10/19/95	608.62	85	07/22/96	612.29	121
05/15/95	624.22	114	10/26/95	607.29	81	07/25/96	611.67	119
05/18/95	624.38	115	10/30/95	606.54	78	07/29/96	610.87	116
05/22/95	624.52	117	11/02/95	606.04	75	08/01/96	610.21	113
05/25/95	624.58	119	11/09/95	604.73	72	08/05/96	609.78	110
05/30/95	624.72	121	11/13/95	604.67	67	08/12/96	608.72	106
06/05/95	624.52	123	11/16/95	604.66	66	08/16/96	608.20	101
06/08/95	624.38	127	11/20/95	604.42	65	08/19/96	607.83	98
06/12/95	624.15	127	11/27/95	604.35	64	08/22/96	607.49	96
06/15/95	624.25	129	12/07/95	606.30	64	08/26/96	607.06	94
06/19/95	623.95	130	12/11/95	604.24	64	08/29/96	606.76	90
06/26/95	623.65	130	12/18/95	604.68	71	09/05/96	606.01	88
06/29/95	623.45	131	12/21/95	603.85	67	09/12/96	605.22	83
07/03/95	623.22	104	12/26/95	603.15	65	09/16/96	604.76	79
07/06/95	623.02	85	12/28/95	603.16	55	09/30/96	603.46	73
07/10/95	622.72	128	01/04/96	603.26	61	10/03/96	602.96	69
07/13/95	622.52	128	01/08/96	603.17	59	10/07/96	601.83	66
07/17/95	622.28	128	01/11/96	603.15	58	10/10/96	601.07	61
07/20/95	622.08	128	01/18/96	603.17	59	10/17/96	599.42	56
07/24/95	621.75	128	01/25/96	603.62	61	10/22/96	598.42	49
07/27/95	621.58	128	02/05/96	611.72	72	10/24/96	598.50	46
07/31/95	621.28	128	05/13/96	623.82	157	10/28/96	598.75	46
08/03/95	621.02	127	5/16/96	623.59	158	11/01/96	599.01	48
08/07/95	620.45	126	5/21/96	623.06	158	11/07/96	599.30	45
08/10/95	620.02	125	5/23/96	622.83	155	11/14/96	599.49	46
08/14/95	619.48	124	5/28/96	622.14	155	11/18/96	599.36	48
08/17/95	619.05	122	06/04/96	620.36	151	11/25/96	598.85	48
08/24/95	618.15	121	06/06/96	619.93	146	12/05/96	597.84	43
08/28/95	617.62	119	06/10/96	619.34	146	12/09/96	597.70	41
08/31/95	617.28	119	06/13/96	618.90	145	12/12/96	598.49	46

TABLE 4
1993 to 1997 Spillway Underdrain Flow Data
Leroy Anderson Dam
Page 3 of 3

Date	Reservoir Level (ft)	Underdrain Flow (gpm)
06/11/97	615.52	133
06/18/97	615.00	132
06/26/97	614.33	130
07/02/97	613.40	126
07/09/97	612.45	122
07/16/97	611.41	118
08/06/97	607.27	107
08/14/97	605.28	91
08/20/97	603.97	81
08/27/97	602.76	73
09/03/97	601.51	64
09/10/97	600.69	57
09/17/97	600.22	53
09/24/97	599.36	50
10/01/97	598.79	41
10/08/97	598.22	44
10/15/97	596.61	40
10/22/97	595.51	34
10/29/97	595.57	29
11/05/97	594.63	28
11/13/97	593.29	25
11/19/97	592.35	22

Note: Basis of elevations is NGVD 1929



Note: basis of elevations is NGVD 1929

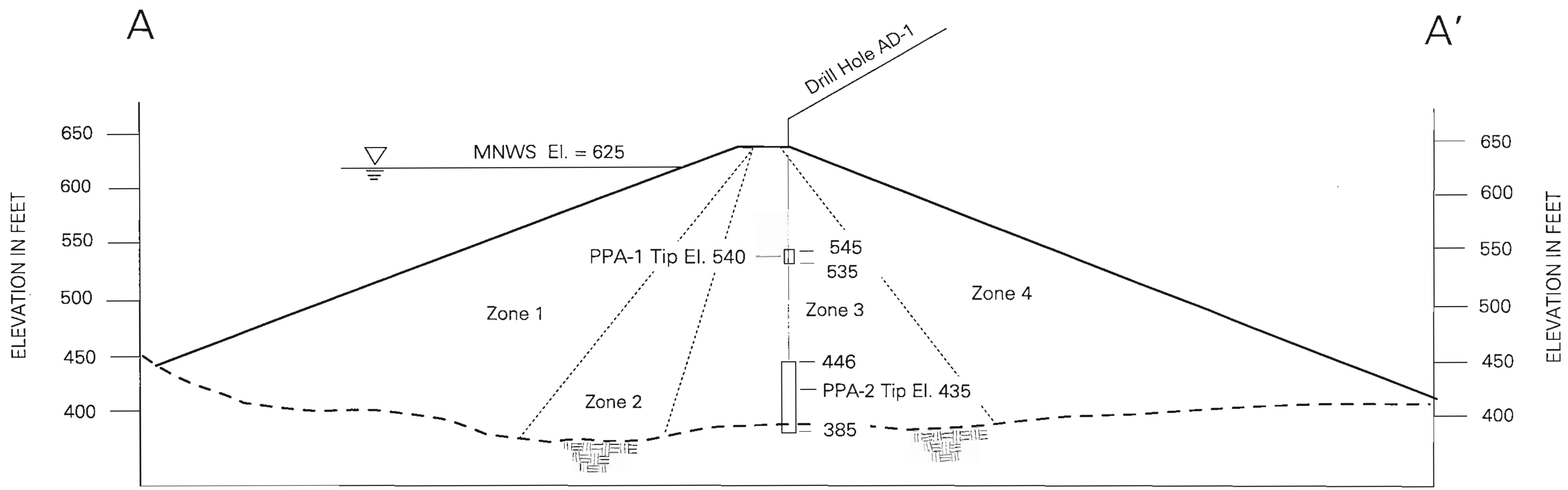
DATE
9/24/96
DESIGN
JLN
DRAWN
JLN
CHECKED
RET

Santa Clara Valley Water District

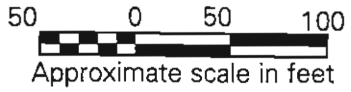
Sketch Plan

Leroy Anderson Dam (No. 72-9)
Surveillance Instrumentation

SCALE
1" = 200'
FIGURE
1

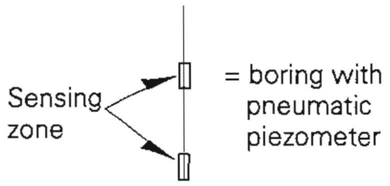


Note: basis of elevations is NGVD 1929



Approximate scale in feet

Explanation



= boring with pneumatic piezometer

DATE 9/24/96 DESIGN JLN DRAWN JLN CHECKED RET	Santa Clara Valley Water District	Cross Section Leroy Anderson Dam (No. 72-9) Piezometer Locations	SCALE 1" = 100' FIGURE 2

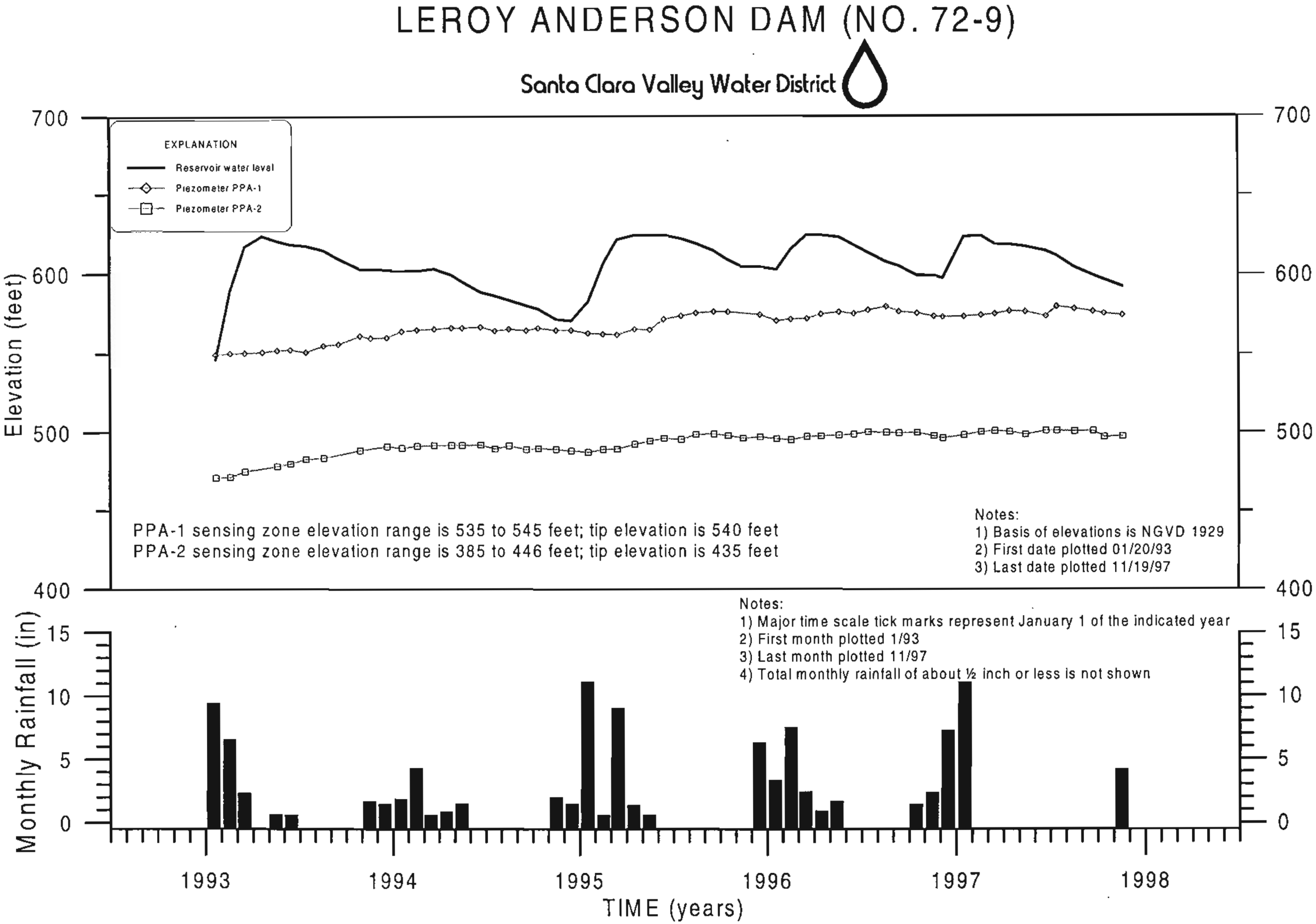
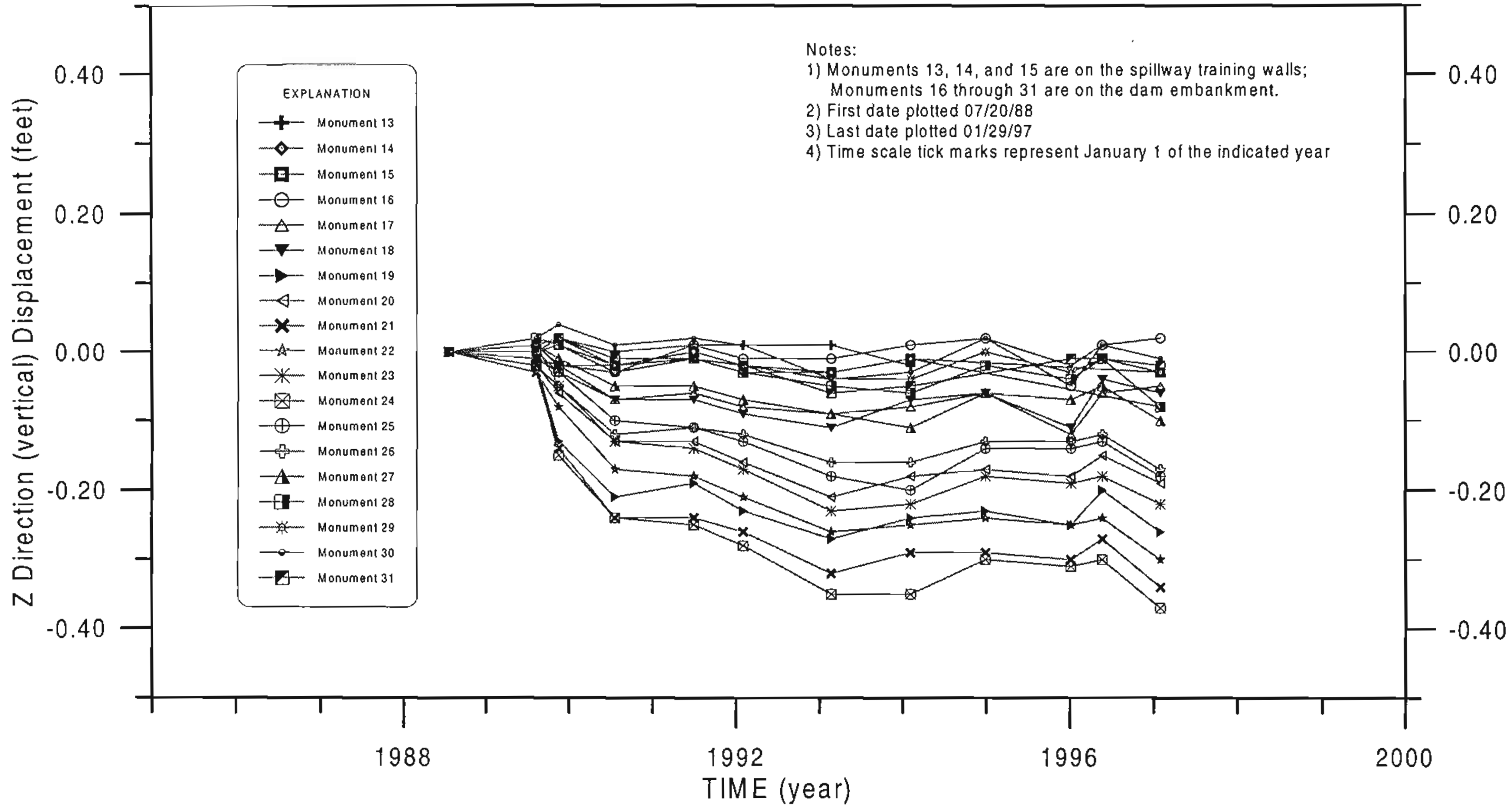


Figure 3. Reservoir Water Level, Piezometric Surfaces, and Monthly Rainfall, January 1993 through November 1997

LEROY ANDERSON DAM (NO. 72-9)

Santa Clara Valley Water District

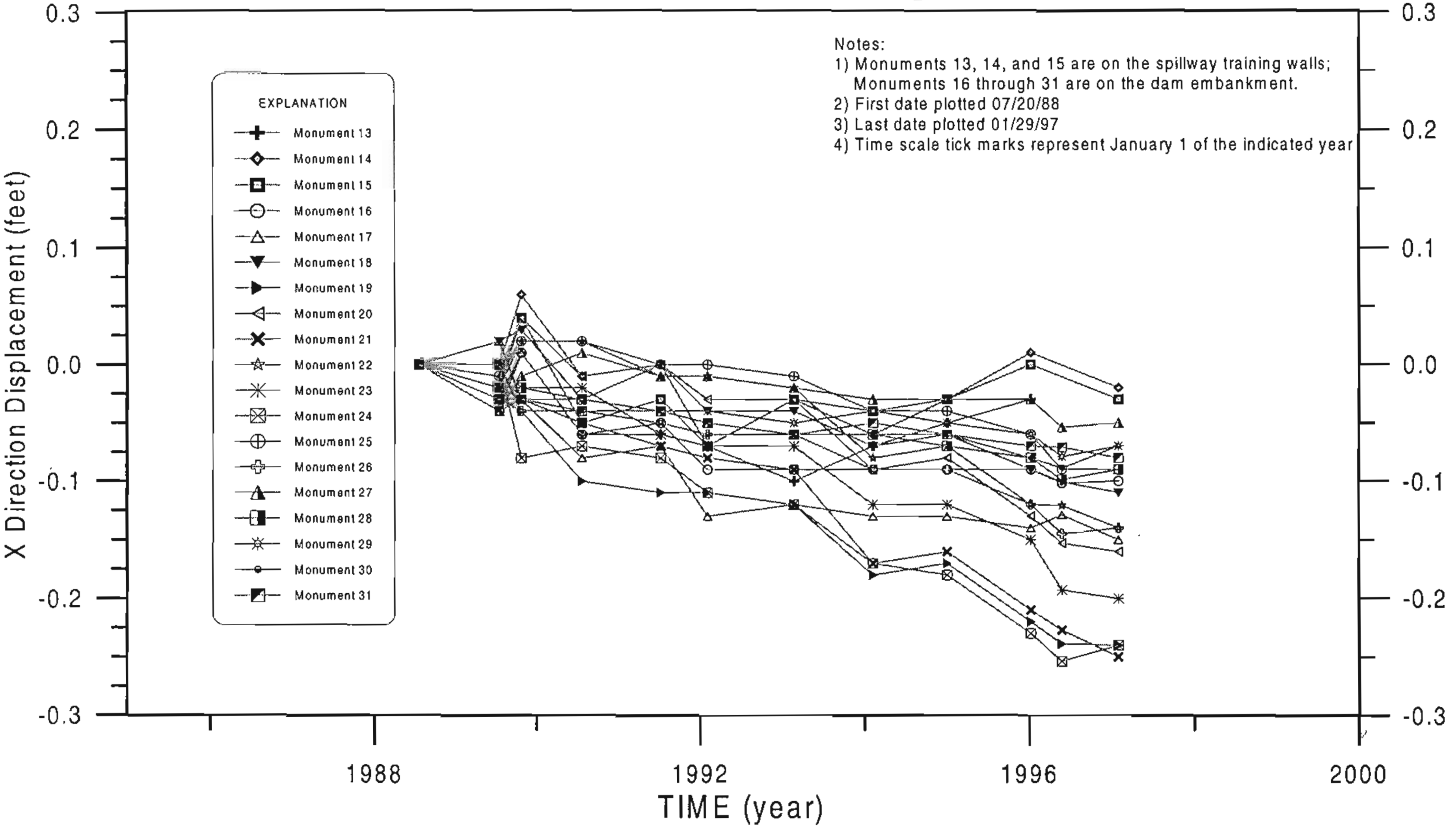


Notes:
1) Monuments 13, 14, and 15 are on the spillway training walls; Monuments 16 through 31 are on the dam embankment.
2) First date plotted 07/20/88
3) Last date plotted 01/29/97
4) Time scale tick marks represent January 1 of the indicated year

Figure 4. Monument Z Direction (Vertical) Displacement Versus Time, July 1988 to January 1997

LEROY ANDERSON DAM (NO. 72-9)

Santa Clara Valley Water District

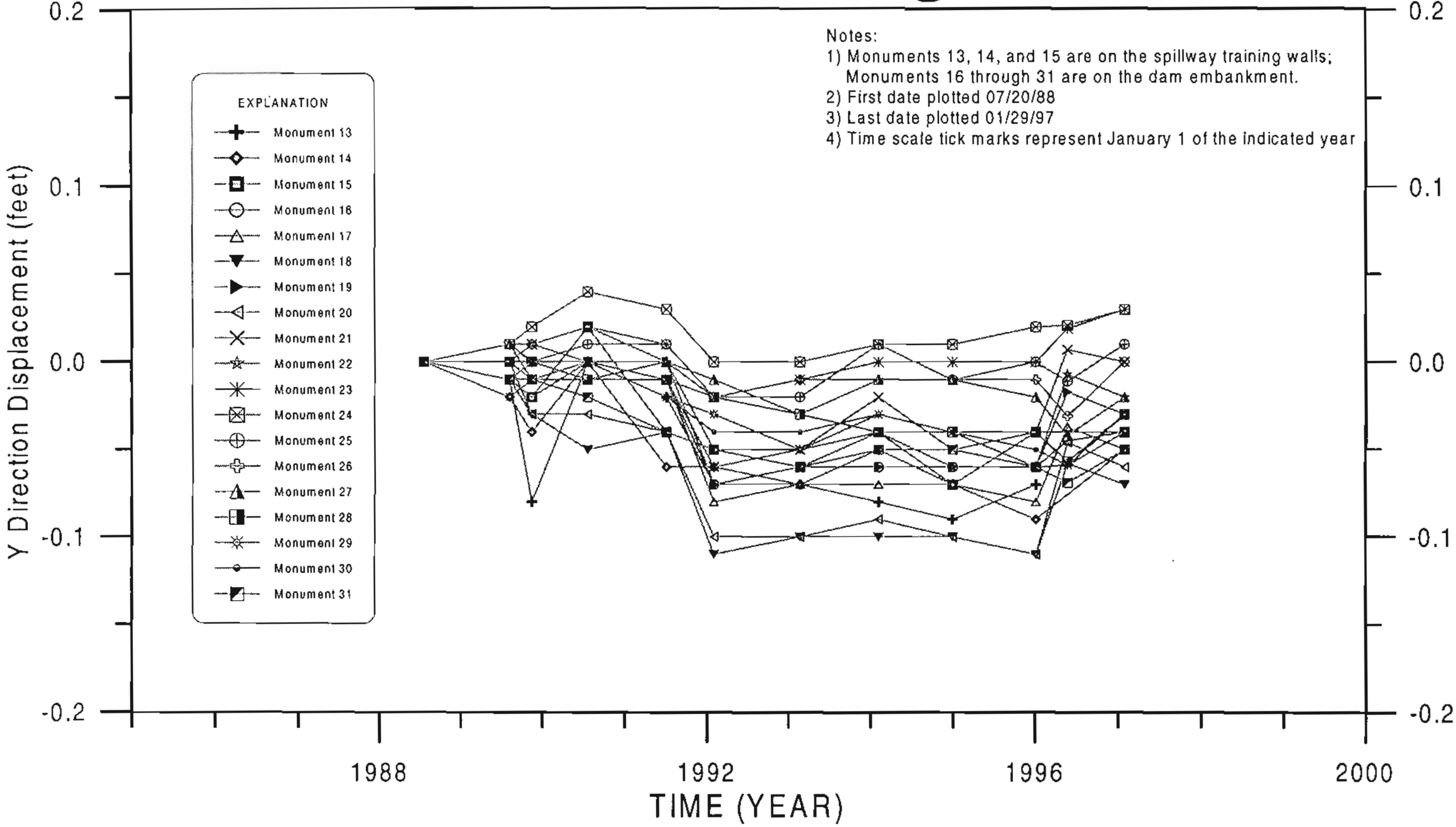


Notes:
1) Monuments 13, 14, and 15 are on the spillway training walls;
Monuments 16 through 31 are on the dam embankment.
2) First date plotted 07/20/88
3) Last date plotted 01/29/97
4) Time scale tick marks represent January 1 of the indicated year

Figure 5. Monument X Direction Displacement Versus Time, July 1988 to January 1997

LEROY ANDERSON DAM (NO. 72-9)

Santa Clara Valley Water District

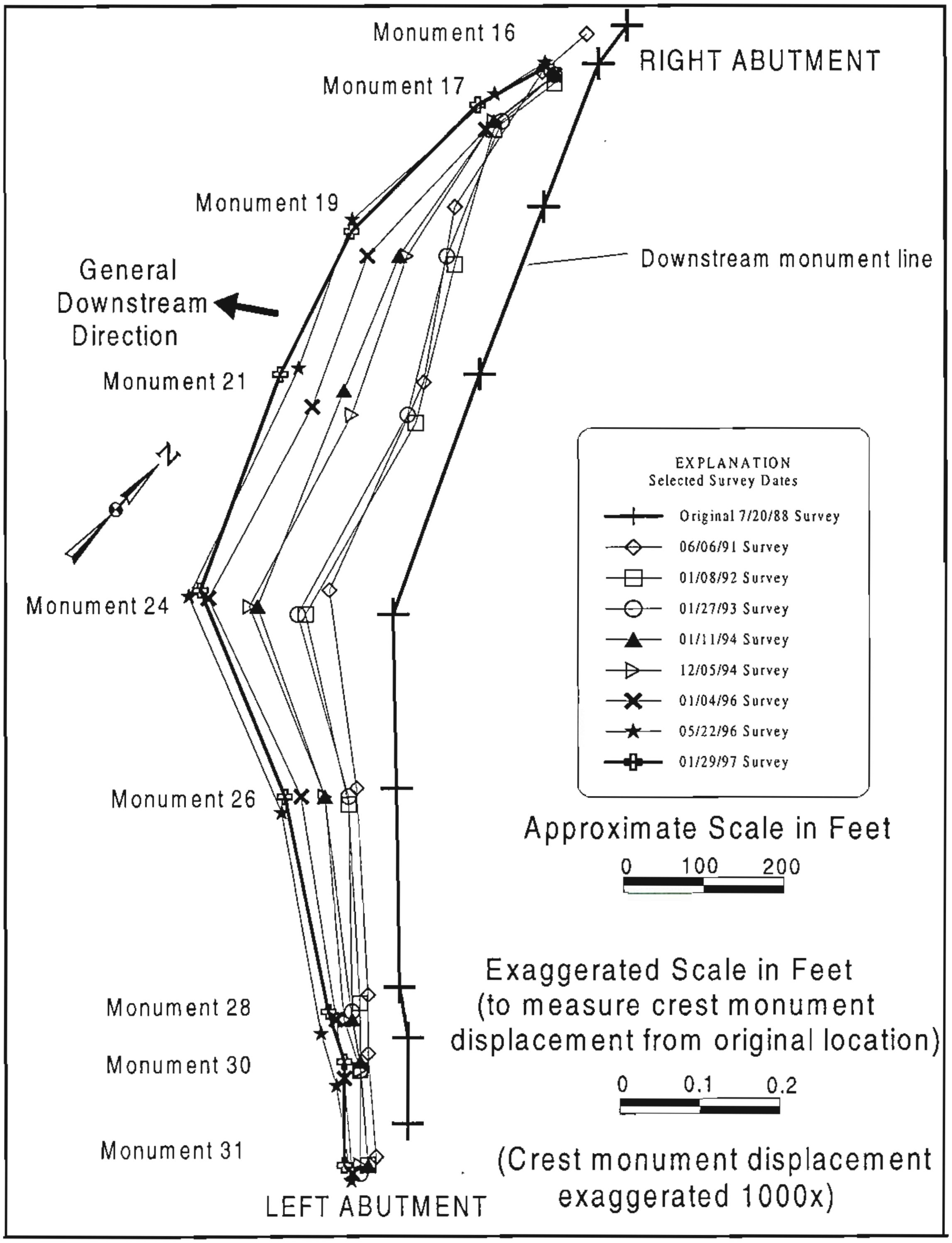


Notes:
1) Monuments 13, 14, and 15 are on the spillway training walls;
Monuments 16 through 31 are on the dam embankment.
2) First date plotted 07/20/88
3) Last date plotted 01/29/97
4) Time scale tick marks represent January 1 of the indicated year

Figure 6. Monument Y Direction Displacement Versus Time, July 1988 to January 1997

LEROY ANDERSON DAM (NO. 72-9)

Santa Clara Valley Water District

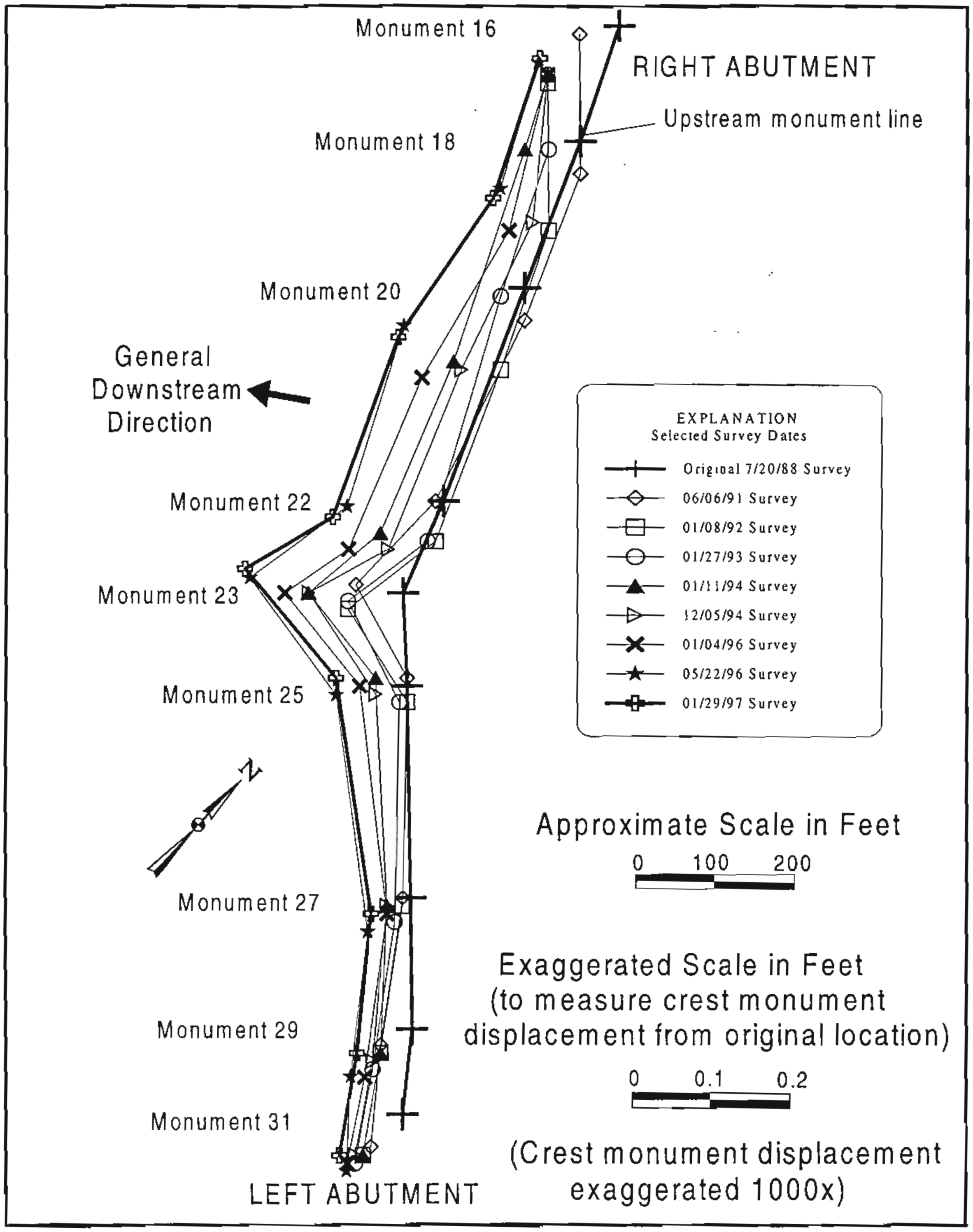


Note: Monuments 16 and 31 are centered on the crest and are included on all plots of downstream and upstream monuments.

Figure 7. Downstream Crest Monument Lateral Location Surveys in Plan View, June 1991 through January 1997

LEROY ANDERSON DAM (NO. 72-9)

Santa Clara Valley Water District



Note: Monuments 16 and 31 are centered on the crest and are included on all plots of downstream and upstream monuments.

Figure 8. Upstream Crest Monument Lateral Location Surveys in Plan View, June 1991 through January 1997

LEROY ANDERSON DAM (NO. 72-9)

Santa Clara Valley Water District

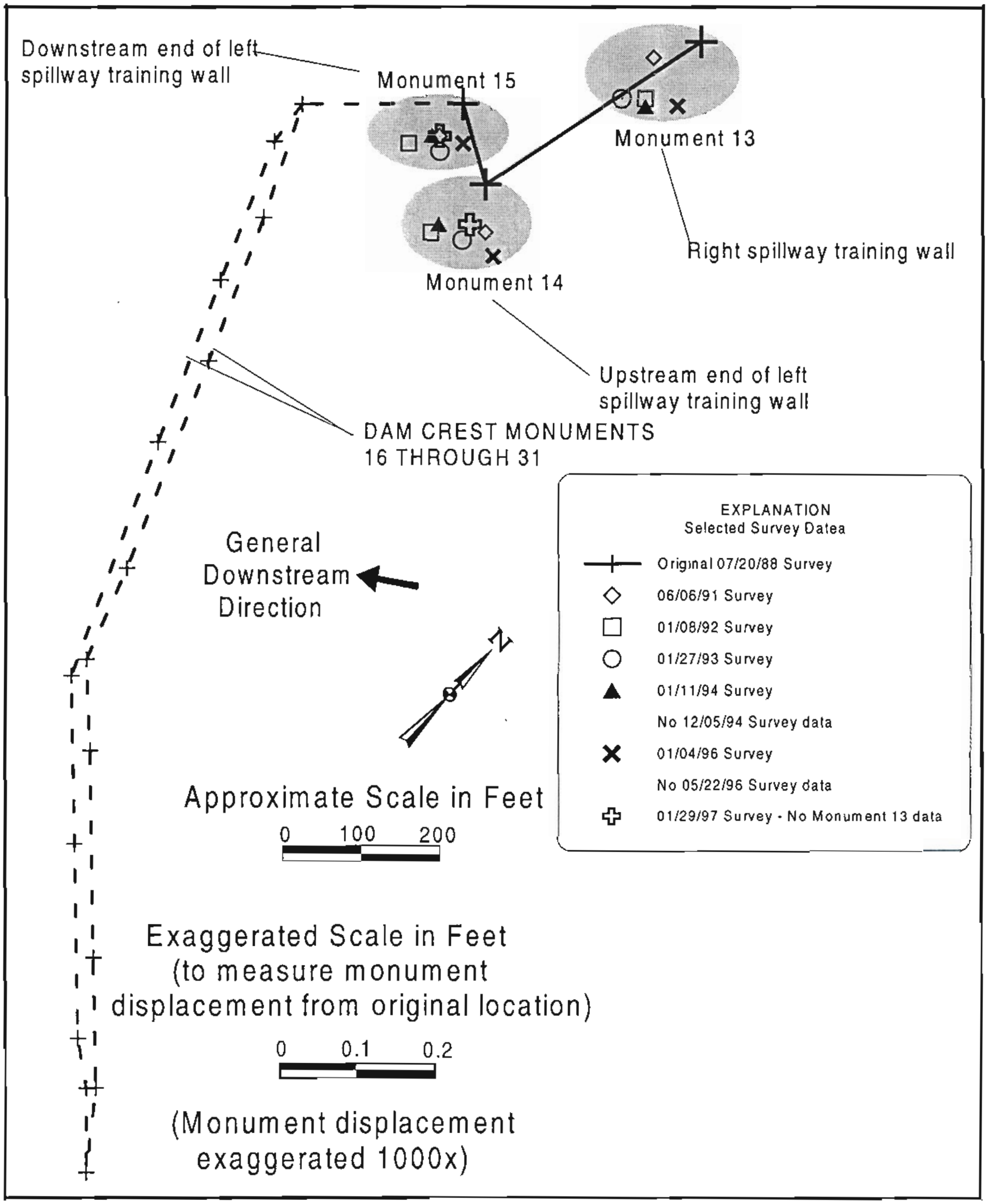

Downstream end of left spillway training wall
Monument 15
Monument 13
Right spillway training wall
Monument 14
Upstream end of left spillway training wall
DAM CREST MONUMENTS 16 THROUGH 31
General Downstream Direction
N
EXPLANATION
Selected Survey Datea
Original 07/20/88 Survey
◇ 06/06/91 Survey
☐ 01/08/92 Survey
○ 01/27/93 Survey
▲ 01/11/94 Survey
No 12/05/94 Survey data
✕ 01/04/96 Survey
No 05/22/96 Survey data
✙ 01/29/97 Survey - No Monument 13 data
Approximate Scale in Feet
0 100 200
Exaggerated Scale in Feet (to measure monument displacement from original location)
0 0.1 0.2
(Monument displacement exaggerated 1000x)

Figure 9. Spillway Training Wall Monument Lateral Location Surveys in Plan View, June 1991 through January 1997

LEROY ANDERSON DAM (NO. 72-9)

Santa Clara Valley Water District

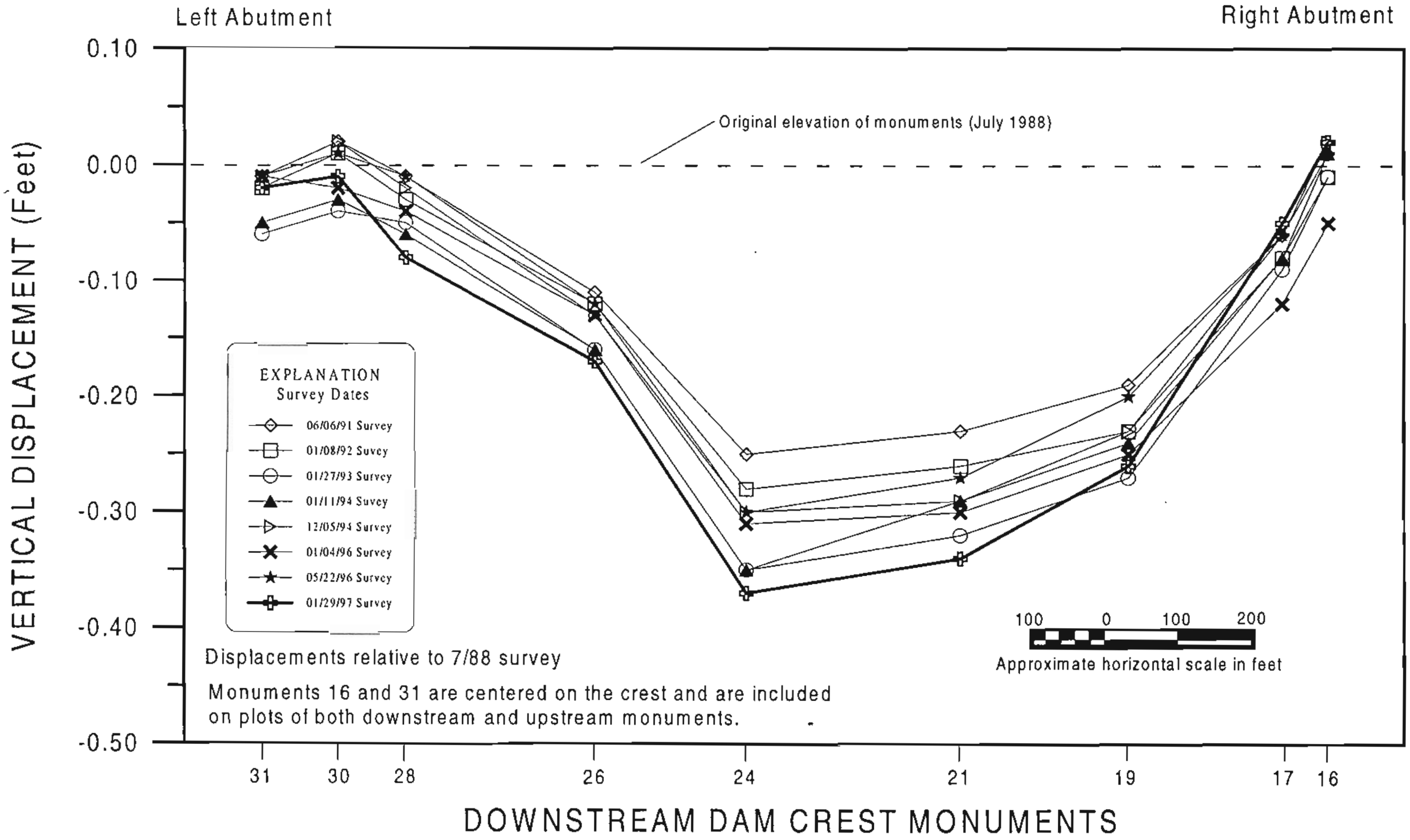


Figure 10. Downstream Crest Monument Vertical Location Surveys in Section View, June 1991 through January 1997

LEROY ANDERSON DAM (NO. 72-9)

Santa Clara Valley Water District

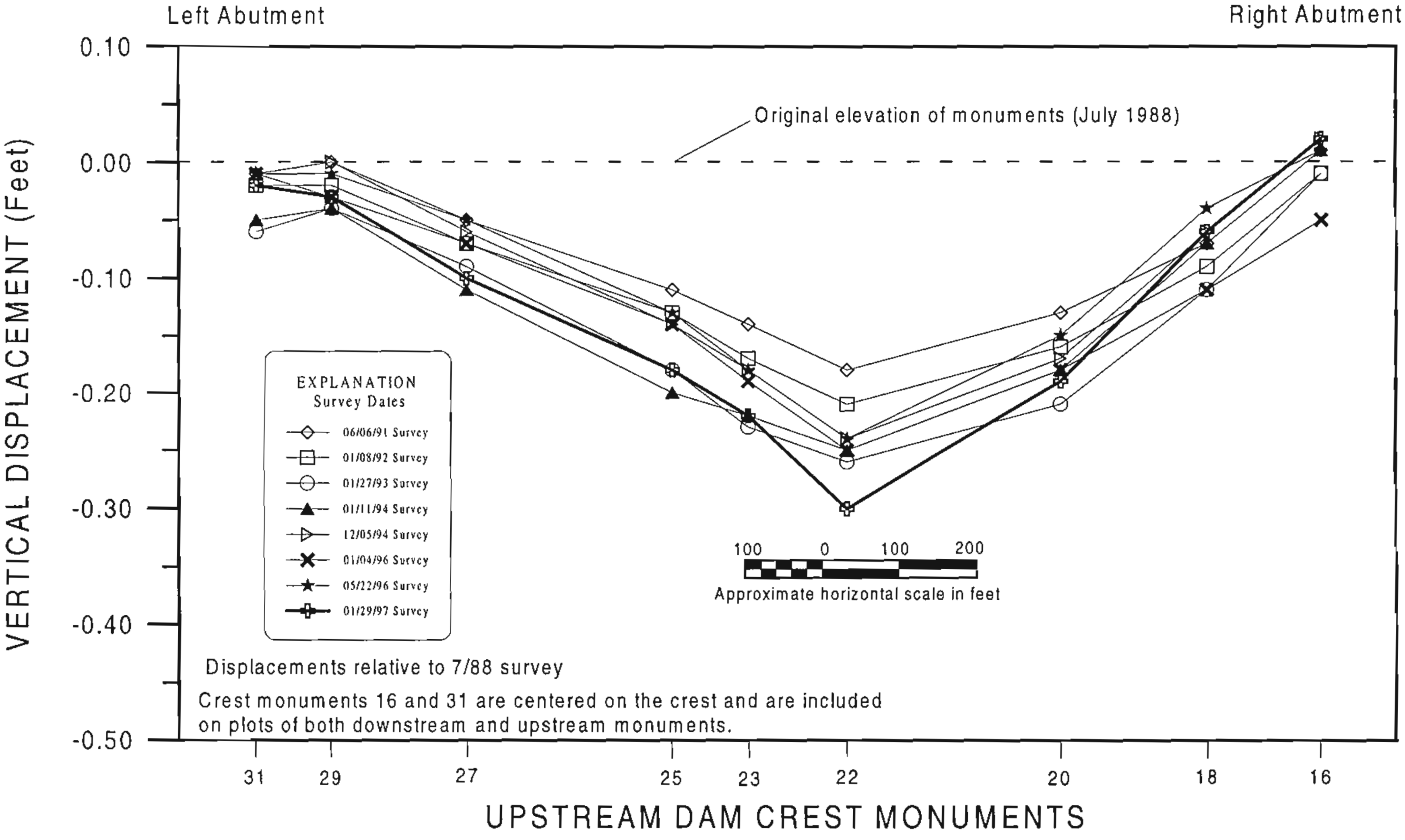


Figure 11. Upstream Crest Monument Vertical Location Surveys in Section View, June 1991 through January 1997

LEROY ANDERSON DAM (NO. 72-9)

Santa Clara Valley Water District

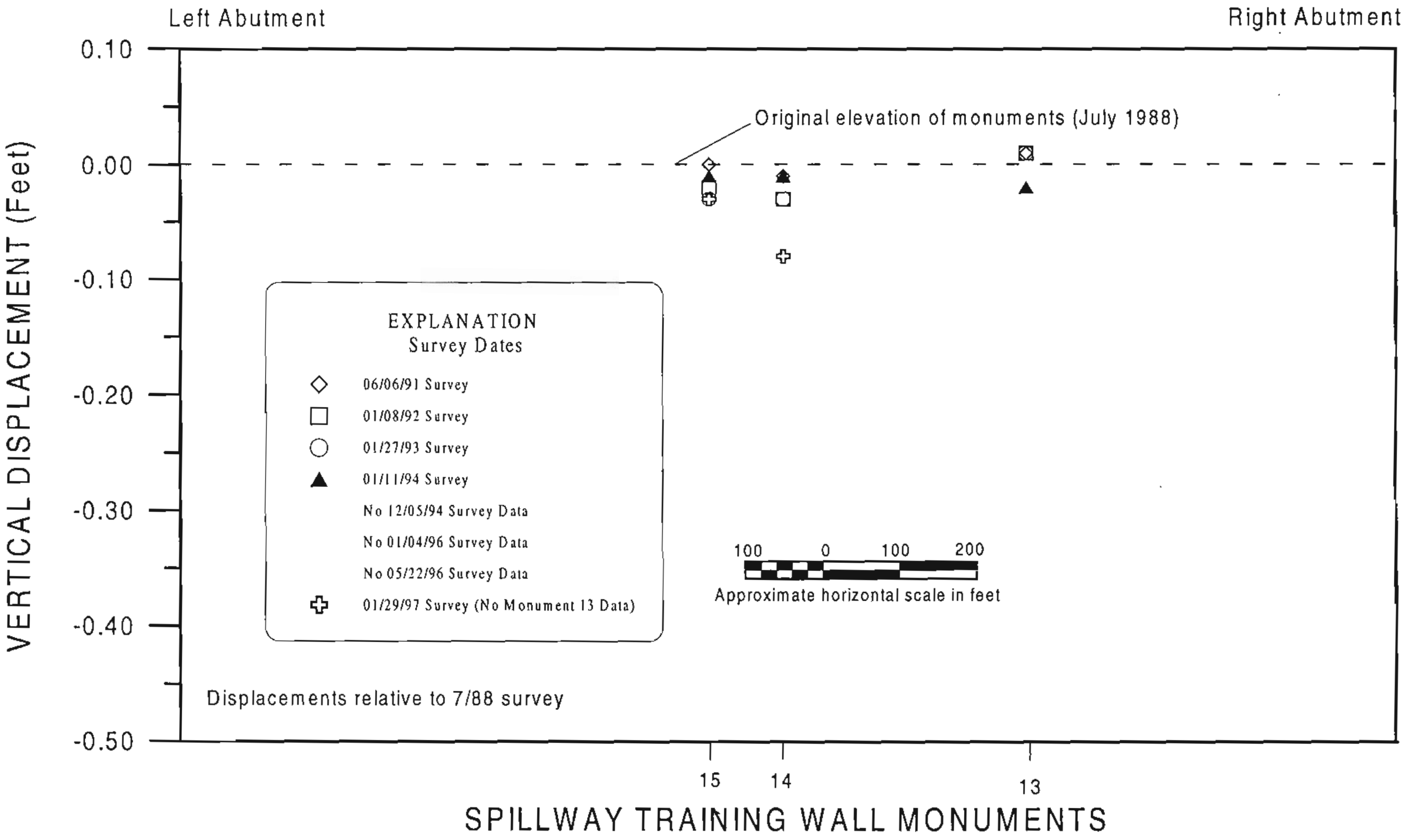
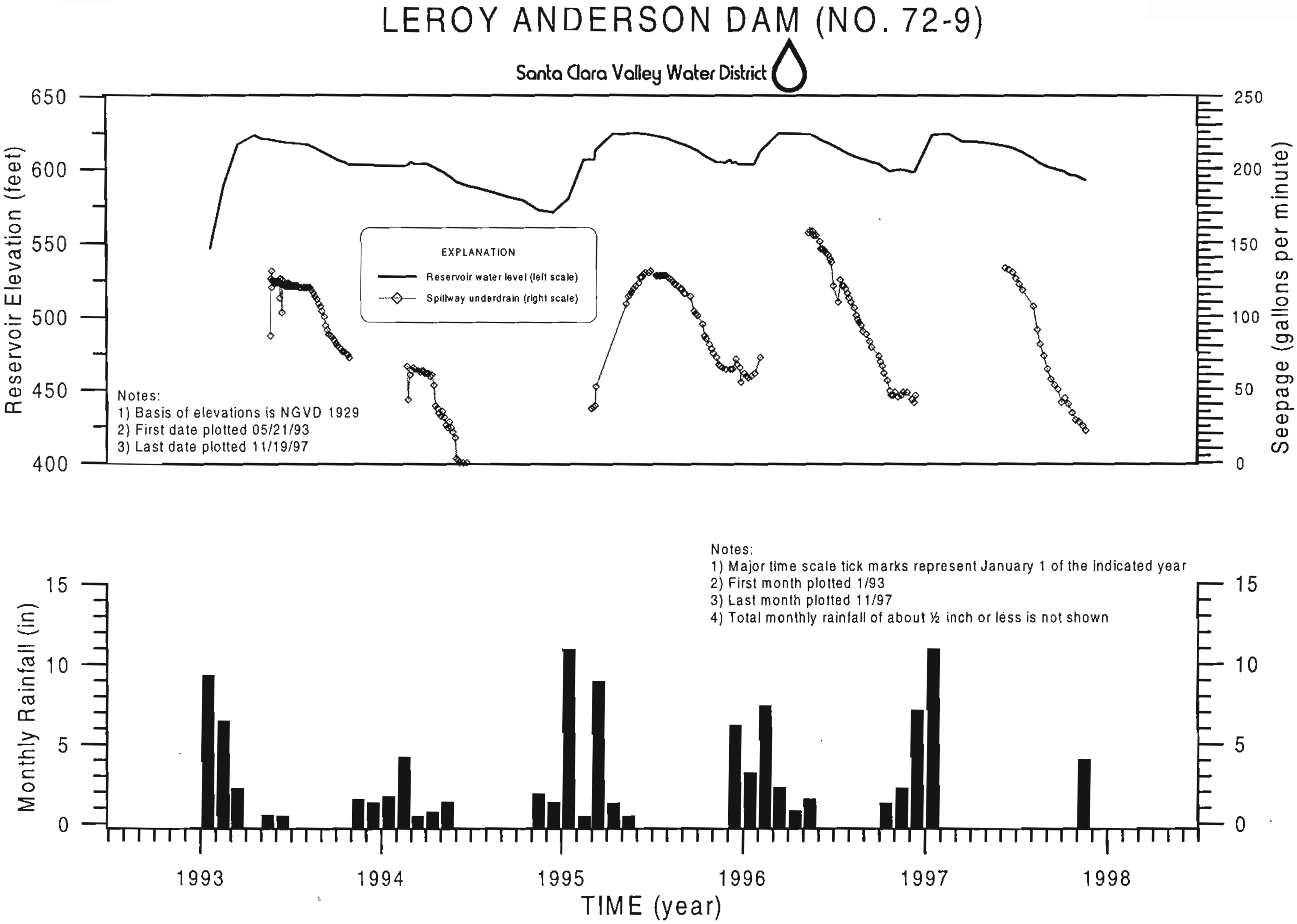


Figure 12. Spillway Training Wall Monument Vertical Location Surveys in Section View, June 1991 through January 1997



Notes:
1) Basis of elevations is NGVD 1929
2) First date plotted 05/21/93
3) Last date plotted 11/19/97

Notes:
1) Major time scale tick marks represent January 1 of the indicated year
2) First month plotted 1/93
3) Last month plotted 11/97
4) Total monthly rainfall of about ½ inch or less is not shown

Figure 13. Reservoir Level, Spillway Underdrain Flow, and Monthly Rainfall, May 1993 to November 1997

LEROY ANDERSON DAM (NO. 72-9)

Santa Clara Valley Water District

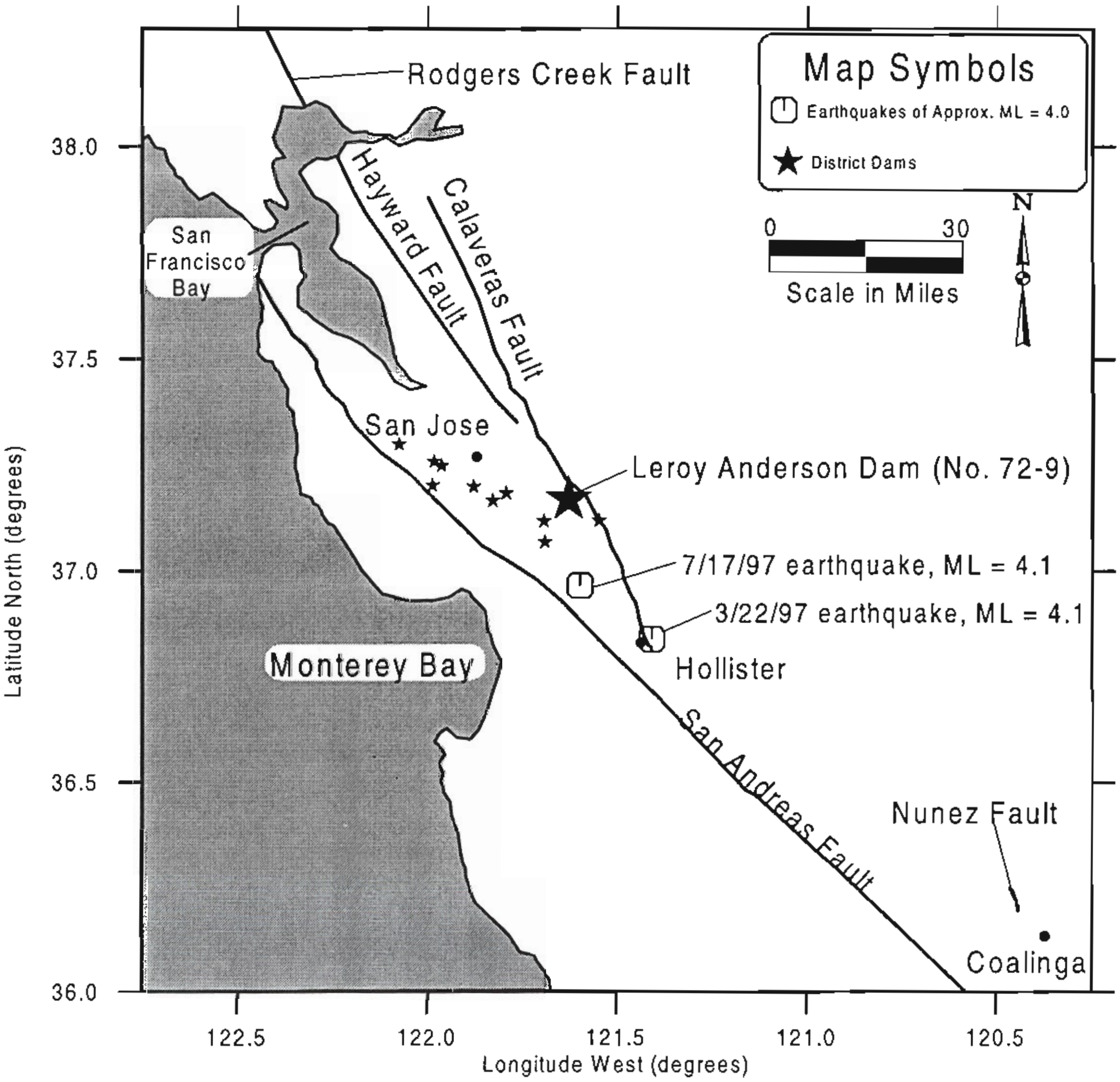


Figure 14. Regional Fault Map, Showing Approximate ML = 4.0 Earthquakes within 50 Miles of Leroy Anderson Dam, January 1997 through November 1997